A Prospective Study of

FUNCTIONAL OUTCOME OF CLOSED SCHATZKER TYPE V AND VI TIBIAL PLATEAU FRACTURES MANAGED BY OPEN REDUCTION AND INTERNAL FIXATION

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CERTIFICATE

This is to certify that this dissertation in **"PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME OF CLOSED SCHATZKER TYPE V AND TYPE VI TIBIAL PLATEAU FRACTURES MANAGED BY OPEN REDUCTION AND INTERNAL FIXATION"** is a bonafide work done by **Dr. K. R. KANNAN** under my guidance during the period June 2006 – November 2008. This has been submitted in partial fulfillment of the award of **M.S. Degree in Orthopedic Surgery (Branch – II)** by the Tamilnadu Dr. M.G.R. Medical University, Chennai.

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DECLARATION

I, **Dr. K. R. KANNAN,** solemnly declare that the dissertation titled **"A PROSPECTIVE STUDY OF FUNCTIONAL OUTCOME OF CLOSED SCHATZKER TYPE V AND VI TIBIAL PLATEAU FRACTURES MANAGED BY OPEN REDUCTION AND INTERNAL FIXATION"** was done by me at The Government Royapettah Hospital/Kilpauk Medical College, Chennai, during June 2006 - November 2008 under the guidance of my unit chief **Prof. K. NAGAPPAN, M.S(Ortho), D. Ortho.**

The dissertation is submitted in partial fulfillment of requirement for the award of M.S. Degree (Branch – II) in Orthopaedic Surgery to **The Tamil Nadu Dr. M.G.R. Medical University.**

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CONTENTS

CRITERIA FOR RASMUSSEN RADIOLOGIC ASSESSMENT

SUBJECTIVE		POINTS
ARTICULAR DEPRESSION	None	6
	< 5 mm	4
	6 - 10 mm	2
	>10 mm	0
CONDYLAR WIDENING	None	6
	< 5 mm	4
	6 - 10 mm	2
	> 10 mm	0
VARUS AND VALGUS ANGULATION	None	6
	< 10°	4
	10° - 20°	2
	> 20°	0
MAXIMUM	Maximum	18
RESULT	Excellent	18
	Good	12 - 17
	Fair	6 - 11
	Poor	< 6

KNEE SOCIETY SCORE

PATIENT CATEGORY

A. Unilateral or bilateral (opposite knee successfully replaced)
B. Unilateral, other knee symptomatic
C. Multiple arthritis or medical infirmity

CRITERIA	POINTS
PAIN	
None	50
Mild or occasional	45
Stairs only	40
Walking and Stairs	30
Moderate	
Occasional	20
Continual	10
Severe	0
RANGE OF MOTION	
(5 degrees = 1 point)	25
STABILITY (Maximal Movement in Any Position)	
Anteroposterior	
< 5 mm	10
5 - 10 mm	5
> 10 mm	0
Mediolateral	
< 5°	15
6 - 9 degrees	10
10 - 14 degrees	5
> 15 degrees	0
SUBTOTAL	
DEDUCTIONS(Minus)	
FLEXION CONTRACTURE	
5 - 10 degrees	2
10 - 15 degrees	5
16 - 20 degrees	10
> 20 degrees	15
EXTENSION LAG	
< 10 degrees	5
10 - 20 degrees	10
> 20 degrees	15
ALIGNMENT	
5 - 10 degrees	0
0 - 4 degrees	3 points each degree
11 - 15 degrees	3 points each degree
Other	20
TOTAL DEDUCTIONS	
KSS SCORE*	

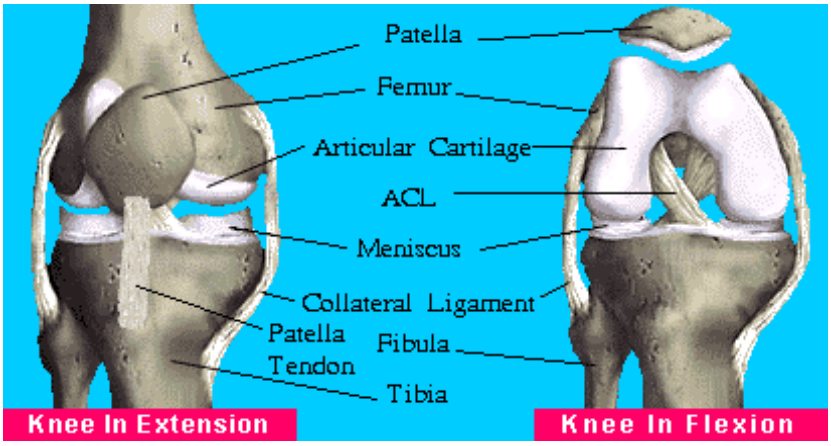
*If total is a minus number, score is 0.

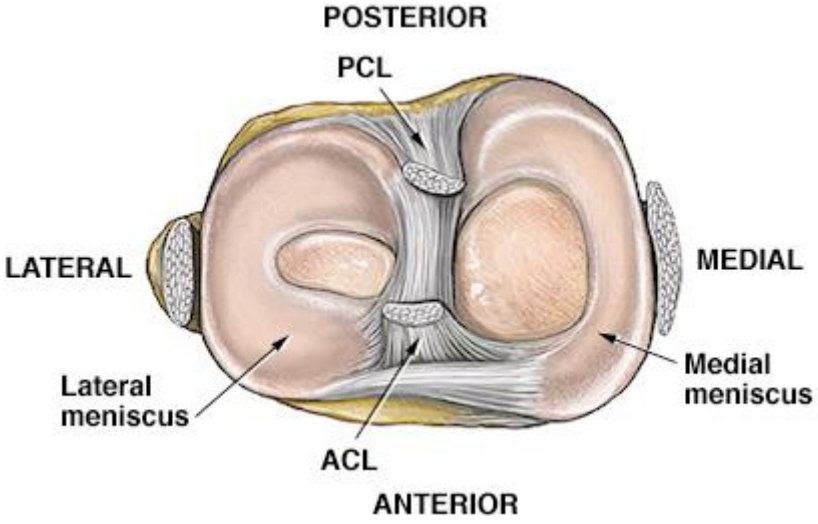
KNEE SOCIETY FUNCTION SCORE

CRITERIA	POINTS
FUNCTION	
WALKING	
Unlimited	50
> 10 blocks	40
5 - 10 blocks	30
< 5 blocks	20
Housebound	10
Unable	0
STAIRS	
Normal up and down	50
Normal up, down with rail	40
Up and down with rail	30
Up with rail; unable down	15
Unable	0
SUBTOTAL	
DEDUCTIONS(Minus)	
Cane	5
Two canes	10
Crutches or Walker	20
TOTAL DEDUCTIONS	
FUNCTION SCORE*	

*If total is a minus number, score is 0.

Anatomy of the knee





INTRODUCTION

Knee joint is an important joint as it is involved in varied functions like load bearing, walking, running, sitting etc. Knee joint is comprised of distal femur, proximal tibia & patella. Injuries of the knee must be treated properly to maintain a good knee function.

Fractures of the tibial plateau represent 1% of all fractures and approximately 8% of fractures occurring in the elderly[1,2]. These are serious injuries resulting frequently in functional impairment.

The goals[3] in treating fractures of the tibial plateau are:

1. to restore the joint space
2. to restore the correct mechanical alignment of the limb
3. to achieve optimal healing of bone, tendon and ligaments and
4. to allow painless full range of motion of the knee.

The optimal treatment of tibial plateau fractures has been a source of controversy for a long time. They were managed both by non-operative and operative methods.

Numerous investigators report satisfactory results using either closed or open treatment methods, especially for the less

severe type injuries that occur as a result of low energy. For the more severe form of injury which results in comminuted tibial plateau fractures (type V and VI) the ideal mode of treatment is always debatable. Conservative mode of management, Open reduction and internal fixation, closed reduction and percutaneous fixation, Hybrid external fixation have all been suggested[4].

In this study we are analyzing prospectively the results of open reduction and internal fixation of these high-energy injuries, which resulted in closed Schatzker type V, VI proximal tibia fractures.

AIM OF THE STUDY

The aim of the study is to analyze prospectively the outcome of closed Schatzker's type V and VI tibial plateau fractures managed by open reduction and internal fixation, by clinical and radiological methods at Government Royapettah Hospital/Kilpauk Medical College, Chennai, between June 2006 to November 2008.

REVIEW OF LITERATURE

Tibial plateau fractures has proved to be a fascinating therapeutic challenge for nearly two centuries of written experience. More than 1100 articles, thesis and books have documented the trial and tribulations of treating this capricious joint fracture - Hohl.

In the early period, proximal tibia fractures were treated with splinters. Since the beginning of the 20th century, there has been a steadily increasing trend towards operative reduction in the treatment of proximal tibial fracture. Now the option of treatment for these fractures are varied like plates, intramedullary devices, and external skeletal fixation devices.

Open reduction and internal fixation for tibial fracture was first done by Stichbach with silver plates and galvanized steel screws – 1900.

Fessbander did the first open reduction for tibial plateau fracture – 1901. Wilms used two nails to hold the reduction – 1910. Dehelly used grafts under surgically elevated plateau after open reduction – 1927.

Tibial plateau fractures were treated predominantly by traction or immobilization in splint – early 1950s.

Apley pioneered early joint rehabilitation and developed successful methods of traction that permitted early motion of joints while providing sufficient immobilization for the fracture to unite. He applied these techniques to the treatment of tibial plateau fractures and reported satisfactory results comparing with the results of surgery – 1956.

AO/ASIF[5] group developed atraumatic techniques of open reduction and stable fixation which permitted absolute stability of fixation and early motion without fear of displacement, malunion, or nonunion. They also developed new implants and instruments that facilitated the attainment of the new goals of ORIF- 1958.

Charnley[6] recognized that anatomic reduction and early motion were desirable in the treatment of intra-articular injuries, but the techniques of surgery and internal fixation available at that time made these objectives of treatment unattainable – 1961.

Rasmussen[7] showed a high correlation between post-traumatic osteoarthrosis and residual condylar widening or discontinuity between the tibial plateau surfaces and the femoral condyles – 1973.

Schatzker, McBroom, and Bruce[8] reported their experience with surgical stabilization of select tibial plateau fractures in which 89% of patients had acceptable results – 1979.

Mitchell and Shepard, in their studies of the effects of articular malreduction and unstable fixation on the outcome of articular fractures, showed that accurate reduction and stable fixation of intra-articular fragments are necessary for articular cartilage regeneration and that malreduction and instability result in rapid articular cartilage degeneration – 1980.

Lansinger and colleagues[9] found good to excellent results in 90% of patients with stable knees at 20 years follow-up – 1986.

Kettlekamp[10] and co-workers suggested that the maintenance of the correct mechanical axis at the knee is a major factor in determining the functional outcome and in the prevention of osteoarthrosis – 1988.

Brown indicated that elevation of contact pressure occurs in a joint when the articular step-off or incongruence is greater than 3mm – 1988.

Mast and colleagues advocated contemporary surgical techniques for more complex injuries, which included concepts

such as indirect reduction, antiglide fixation and composite fixation – 1989.

Honkonen[11] concluded that radiographic appearance of osteoarthrosis and degenerative joint disease does not always correlate with the clinical picture – 1995.

Ahmad M. Ali, Maria Burton, Munawar Hashmi, Michael Saleh, in their study on Outcome of complex fractures of the tibial plateau treated with a beam-loading ring fixation system have shown good clinical results and satisfactory radiological results – 2003.

Robert D. Welch, Hong Zhang, Dwight G. Bronson in their Experimental tibial plateau fractures augmented with calcium phosphate cement or autologous bone graft have shown calcium phosphate cement may serve as a suitable alternative to autologous bone grafting for filling bone voids associated with displaced fractures of the tibial plateau – 2003.

Edwin, Geoffrey, Adam, Komal and David showed acceptable results in 82.7% patients clinically and 82.1% radiologically in their study on operative treatment of tibial plateau fractures in patients older than 55 years – 2004.

SURGICAL ANATOMY

The medial and lateral tibial plateau, separated by the intercondylar eminence of proximal tibia, are the articular surfaces of the medial and lateral tibial condyles and they articulate with the medial and lateral femoral condyles respectively. The medial plateau is larger of the two and is concave in both the sagittal & coronal plane. The lateral plateau is smaller and is convex in the sagittal plane & flat to slightly convex in the coronal plane.

The articular cartilage of the lateral tibial plateau is thicker than the medial plateau. The lateral plateau is higher than the medial plateau. The medial plateau rests deeper in the proximal tibia than the lateral plateau. The different levels of the plateau are of significance for arthroscopic portals and K-wire placement. Screw inserted from lateral to medial in the subchondral bone if placed perpendicular to the tibial shaft, will penetrate the articular surface of the medial plateau[12]. Intermeniscal ligament connects the anterior horn of two menisci, while the coronary ligaments attach periphery of the menisci to the peripheral rim of their respective tibial plateau[13].

The tibial plateau is composed of a medial, lateral and posterior flare of the proximal tibia that results in a medial and

lateral condyle. The medial condyle has less of a flare, and thus is less prone to the shear forces that make the lateral plateau more susceptible to fracture.

In relationship to the long axis of the tibia, the surface of the plateau has a 10 degrees posterior slope. This must be remembered while placing subchondral screws from front to back to avoid penetration into the posterior aspect of the joint.

The non-articular area between the plateau, contains anterior and posterior tibial spine. Anterior tibial spine is more medial & just posterior to the insertion of the ACL. The posterior cruciate ligament is attached in the posterior intercondylar area, extending onto the posterior surface of the metaphysis. It is important to restore the width of intercondylar eminence, to appropriately restore the anatomic width of the proximal end of the tibia[1].

The tibial tubercle is located on the anterior & lateral tibial crest 2 to 3 cm below the anterior joint line and provides attachment for the patellar tendon. The Iliotibial band inserts along the lateral tibial flare into a prominence known as Gerdy's tubercle. The fibular head is prominent along the posterolateral aspect of the tibial condyle and the fibular collateral ligament and biceps

tendon gets inserted to it. The fibula buttresses the lateral tibial condyle .

The lateral plateau has an average 4 mm thick hyaline cartilage articular surface that is nearly covered by the lateral meniscus. The medial plateau has an average 3mm thick hyaline cartilage articular surface covered by the medial meniscus for about one half leaving the other half exposed. The important function of Menisci is in load sharing by protecting the articular cartilage from upto 60% of the load encountered by the knee[1,14]. The meniscotibial ligaments attach these structures to the tibia. These structures should be identified and incised horizontally to gain visualization of the joint through a submeniscal exposure.

In normal knee, load is predominantly borne on the medial side, consequently the trabecular bone on the medial tibial condyle is stronger than that on the lateral condyle[12]. Hence fractures of the lateral plateau are more common and occur as a result of a low energy mechanism. When fractures of the medial plateau occur, they are invariably associated with more violent injuries and more commonly are associated with more tissue injuries, such as disruptions of the lateral collateral ligament complex, lesions of the peroneal nerve or damage to the popliteal vessels[3].

For medial opening of the joint, MCL provides 57% restraining moment with 15% from ACL and 25% from joint capsule at 5 degree of knee flexion. MCL provides 78% of restraining moment at 25 degrees of knee flexion. LCL provides similar amount of restraining moment at 25 degrees of knee flexion[15].

MECHANISM OF INJURY

Fractures of the proximal tibia were originally described as *"the fender fracture"* as they resulted primarily from low-energy pedestrian versus car bumper accidents. Nowadays the majority of tibial plateau fractures reported in the recent literature have resulted from high-speed motor vehicle accidents and fall from height[12].

Injuries to the tibial plateau occur as a result of

- A force directed either medially (valgus deformity, the classic "bumper fracture") or laterally (varus deformity)
- An axial compressive force or
- Both an axial compressive force and bending load from the side[15].

With the knee in full extension, the anterior aspect of the femoral condyle is wedge shaped & the force generated by the injury drives the condyle into the tibial plateau. The direction, magnitude and location of the force as well as the position of the knee at impact determines the fracture pattern, location and degree of displacement.

When a single compartment is involved in fractures of the tibial plateau, it is usually the lateral plateau. This is because the

anatomic axis at the knee joint (which is normally in 7^{o} of valgus) as well as the mechanism of injury usually causes a direct force from lateral to medial.

Pure split fractures are more common in younger patients, in whom the strong subchondral bone is able to withstand the compressive force of the overlying femoral condyle but the shear component of the load produces a split in the condyle with ligamentous disruption.

In the elderly, osteopenic subchondral bone is no longer able to withstand compressive forces. As a result, split depression fractures become common in patients after the fifth decade. These fractures typically result from low-energy injuries, usually simple slip and fall accidents.

In high-energy injuries, the forces may be so great that the plateau explodes into numerous fracture fragments. This mechanism is seen typically after a fall from a height or after a motor vehicle accident occurring with an axial load delivered to an extended knee with or without bending force.

In addition to the fracture there may be associated injuries like Meniscal tear, cruciate tear, collateral ligament injury & soft tissue contusions[16].

CLASSIFICATION

A comprehensive classification of tibial plateau fractures should group fractures that are similar in topography, morphology and pathogenesis requiring similar treatment & having similar prognosis[17]. There are numerous classification systems in use. Associated soft tissue injuries have significant role in prognosis[16]. No classification system covered both the bony and soft-tissue injury[17].

- OTA/AO classification
- Schatzker classification
- Hohl and Moore classification
- Rasmussen classification

AO CLASSIFICATION

In the AO classification, an initial numerical term specifies the injury location. The first digit indicates the involved bone, and the second indicates the involved portion. The proximal tibia is denoted as segment 43, in tibial plateau fracture including extraarticular fracture, partial and complete articular fractures[1,12].

A = Extraarticular fracture

-A1 Avulsion fracture

-A2 Simple metaphyseal fracture

-A3 Comminuted metaphyseal fracture

B = Partial articular fracture

-B1 Partial articular fracture, pure split

.1 of the lateral surface

.2 of the medial surface

.3 oblique, involving the tibial spines and one of the surfaces

-B2 Partial articular fracture, pure depression

.1 lateral total

.2 lateral limited

.3 medial

-B3 Partial articular fracture, split-depression

.1 lateral

.2 medial

.3 oblique, involving the tibial spines and one of the surfaces.

C = Complete articular fracture

-C1 Complete articular fracture, articular simple, metaphyseal simple

.1 slight displacement

.2 one condyle displaced

.3 both condyles displaced

-C2 Complete articular fracture, articular simple, metaphyseal multifragmentary

.1 intact wedge

.2 fragmented wedge

.3 complex

-C3 Complete articular fracture, multifragmentary

.1 lateral

.2 medial

.3 lateral and medial

SCHATZKER CLASSIFICATION

This is the most commonly followed classification for tibial plateau fracture. It incorporates topographical & morphologic characteristics, pathophysiologic factors & treatment. It is queued according to the severity of the fracture. There are six types each representing a group of fractures that are similar in mechanism of injury, fracture pattern, and prognosis[8,17,18].

Type I

Type I is a pure split fracture with wedge shaped fracture fragment of the lateral plateau, due to valgus and axial forces. It occurs in young persons in whom the strong cancellous bone of the plateau resists depression.

TYPE II

Type II is a split-depression fracture of the lateral plateau. The mechanism of injury is similar to type I, a lateral bending force

with combined axial loading. It usually occurs in patients in their fourth decade of life or later.

TYPE III

Type III is a pure depression of the lateral plateau with an intact osseous rim. It is common in patients in fourth or fifth decade.

TYPE IV

Type IV is a fracture of the medial tibial plateau. Based on topographic, treatment significance, medial tibial plateau fracture is further subclassified into Type-A split fracture, Type-B Depression fracture[12]. The injury results from varus and axial loading forces. The medial plateau resists fracture more than the lateral due to stronger trabecular pattern and therefore they occur as a result of much greater force.

TYPE V

Type V is a bicondylar fracture that involves a split of the lateral and medial plateau. It often forms an inverted Y shaped with metaphysis, diaphysis being intact. They occur as a result of pure axial load applied to the extended knee. It may also involve varying degrees of articular depression and displacement of the condyles.

TYPE VI

Type VI are high-energy complex fractures with varying degree of comminution of one or both tibial condyles involving the articular surfaces as well as the separation of the metaphysis from the diaphysis, so called diaphyseo-metaphyseal dissociation. In 1992, Honkonen & Jarvinen have modified type VI based on limb alignment as medially tilting & laterally tilting[19].

HOHL AND MOORE CLASSIFICATION

This focuses on fracture-subluxation. The patterns described are indicative of fractures with a higher incidence of soft-tissue injuries, including ligamentous, meniscal, and neurovascular which are often seen in combination[20,21,22].

TYPE 1

These are split fractures of the medial tibial plateau in the coronal plane. The fracture line may extend into the lateral condyle and even the fibular head.

TYPE 2

These are entire condyle fractures. They are distinguished from Schatzker types I and IV by the inclusion of the tibial eminence in the main condylar fragment.

TYPE 3

These are rim avulsion fractures. Rim avulsions occur because of severe valgus/varus stresses, causing the ligamentous attachments of the collateral and capsular ligaments to avulse the bony rim of the respective plateau. This type is associated with a high rate of neurovascular injury[12,22].

TYPE 4

These injuries are rim compression fractures. They also result because of severe varus or valgus forces. The difference is that the opposite collateral ligament ruptures, which allows impaction of the rim of the plateau by the opposite femoral condyle, causing localized rim compression.

TYPE 5

This is a four-part fracture consisting of both condyles, disruption of both collateral complexes, and separation of the tibial eminence. These are highly unstable fractures.

RASMUSSEN'S CLASSIFICATION

Rasmussen's classification is used as an indication for operative intervention based on the clinical stability of the knee in full extension. A knee was considered unstable if it had 10 deg of varus or valgus instability in extension under anesthesia. Unstable knees were indicated for operative stabilization[23].

SOFT TISSUE INJURIES

Soft tissue injuries should be anticipated and routinely looked for in tibial plateau fractures especially in high-energy fracture patterns. These soft tissue injuries can have a significant effect on the functional outcome of the knee[24].

The soft tissue injuries associated with tibial plateau fractures are

- Meniscal injuries
- Ligamentous injuries
- Vascular injuries and
- Peroneal nerve injuries

One should be aware of the possibility of collateral or cruciate ligament injury in tibial plateau fractures. Tender areas usually on the opposite side of fracture along the course of the ligament suggests a ligament injury. Stress testing is better examined preoperatively under anesthesia along with the stress X-rays. Instability can be either due to ligament injury or fracture itself. If stress X-ray shows widening of the joint space, culprit is usually the collateral ligament. Treatment is usually decided upon the degree of the instability after fracture fixation. If the instability is more than 10 degrees ligament repair is considered[9,25].

Cruciate ligament injuries can occur especially in split compression fractures, which have to be treated accordingly. Ruptures of the anterior cruciate have been reported in upto 23% of high-energy injuries[12].

Meniscus is the most vulnerable soft tissue in tibial plateau fractures. The incidence of meniscal injuries is upto 50%[12]. With the advent of arthroscope and pre-op MRI the incidence can still go high. The diagnosis is usually made during the surgery or arthroscopic examination. Meniscal injuries are not serious enough in relation to the osseous injuries to be clinically important or they healed during treatment of fractures. Only the irreparably damaged meniscus has to be excised. Routine removal of meniscus is not recommended for fracture visualization. Peripheral suturing, minor trimming can salvage most torn or displaced meniscus[16].

Popliteal artery is at risk at the level of trifurcation, since this is the fixed part of the artery. Periodic observation of the circulatory status is essential since obstruction can occur within few days of injury. Either direct trauma or stretch can damage the Peroneal nerve.

DIAGNOSIS

HISTORY

The patient is rarely able to relate the exact mechanism of injury, but the history is nevertheless very useful because it permits us to determine the direction of the force, the deformity produced, and whether the injury was caused by a high or a low–velocity force. This information has an important bearing on the associated soft tissue injuries, such as fracture blisters, arterial injury, compartment syndrome, neurologic and ligament injuries[26].

CLINICAL EVALUATION

Physical evaluation is extremely important, as it is the first hand method by which the soft tissue injuries, vascular, neurologic injuries can be diagnosed & further evaluated. The examination should focus on colour, texture, the continuity of the soft tissue envelope and the presence of blisters or superficial abrasions. Deep contusions, hemorrhagic blisters and lack of skin wrinkles all indicate an internal degloving injury[26]. In the presence of some of these findings surgery should be delayed or temporized until the soft tissue envelope has recovered sufficiently[1,3].

Physical examination provides the invaluable opportunity for diagnosis & evaluating the neurologic & vascular status of the

extremity and the most rapid means of assessing the vascular status and the presence or absence of a major tear of a collateral ligament. Presence of feeble peripheral pulse, pain on passive stretch, paresthesia, change in colour, diffuse tense swelling evokes the doubt of compartment syndrome. If the ankle-brachial index is less than 0.9 arteriography is done to delineate further treatment[27]. Examination of ligaments, menisci is of paramount importance but it is too painful for the patient in acute setting. Ligaments examination can be done in the theatre under anesthesia.

INVESTIGATIONS

STANDARD RADIOGRAPHIC VIEWS

Radiographic evaluation starts with a standard knee Antero-posterior, lateral and Plateau view — a 10 degree caudal tilt anteroposterior (Moore view) radiograph. The Moore view takes into account the posterior slope of the plateau, which allows better visualization of the joint surface[28]. The two standard views are inadequate and must be supplemented with two oblique projections taken with the leg in internal and external rotation. Traction radiographs are an additional tool to be used in determining the efficacy of distraction techniques. Traction films

reveal whether ligamentotaxis reduction is possible and also aid in planning surgical incisions[12].

COMPUTED TOMOGRAPHY SCANNING

Computed tomography with axial, coronal and sagittal reconstructions is an extremely helpful, almost essential form of imaging for complex fractures. It allows us to formulate a three-dimensional concept of the fracture and is useful in delineating the extent and location of condylar fracture lines as well as the location and depth of articular impaction, comminution and displacement[29,30,31]. It facilitates preop planning: the size and location of placement of window for reduction can be determined. It helps to plan for type, size, location of plates & screws.

MAGNETIC RESONANCE IMAGING

MRI is becoming widely used in the preoperative evaluation of plateau fractures because of the high incidence of soft tissue lesions accompanying these injuries. It has been shown to be superior for assessment of associated soft tissue injuries such as meniscal and ligamentous disruptions[32]. Studies have reported the incidence of “internal derangement” indicated by MRI results ranging between 47% to 97% per plateau fracture. The role of MRI in final outcome of fracture remains to be defined clearly[32,33].

ARTERIOGRAPHY

An arteriogram should be considered whenever there is serious concern about the possibility of an arterial lesion[27]. The fracture pattern most commonly associated with an arterial injury is the Schatzker type IV, the fracture of the medial plateau.

TREATMENT

The goals[34] of treatment, like any intra-articular fracture, are

- Anatomic reduction of the articular surface
- Restoration of joint congruity
- Mechanical alignment
- Early mobilization of the joint
- Avoidance of complications

Non-operative treatment is indicated in low energy fracture types, i.e. incomplete or undisplaced fractures, minimally displaced fractures (< 3 mm) which are stable, elderly, low demand patient with osteoporotic bone[1,26,35]. Relative indications for nonoperative treatment are the presence of significant cardiovascular, pulmonary, neurologic or metabolic compromise.

A fracture is considered stable if it does not exhibit, on varus or valgus stressing, more than 10 degrees of instability at any point in the arc of motion, from full extension to 90 degrees of flexion.

Surgical treatment is indicated in all open fractures, fracture associated with acute compartment syndrome or arterial occlusion, fractures that occur in conjunction with multiple injuries (polytrauma patients) and all unstable fractures. More than 5 to 10

degree of instability in medio-lateral plane at any point in the arc of motion from full extension to 90 degrees is accepted as unstable fracture[36].

There is no universal agreement on the amount of articular depression that can be accepted. Ranges from 4 to 10 mm has been described as tolerable[34]. Studies have shown lack of correlation between residual osseous depression of the joint surface and the development of arthrosis. Posttraumatic arthritis is mainly associated with residual instability and axial malalignment.

For type I fractures percutaneous fixation or open reduction and fixation with 6.5 or 7mm cannulated screws, 3.5 mm screws in raft fashion can be done[3,12].

Type II fractures require elevation and bone grafting. Buttress plating may or may not be required depending on the intactness of the fibula.

Type III pattern requires elevation and bone grafting either by arthrotomy or it can be done as arthroscopic-assisted fixation[37]. Meniscal lesions can be treated and valuable diagnostic information can be obtained regarding the cruciate ligaments and articular surface by arthroscopic assisted method[37].

Type IV fracture pattern requires open reduction and medial buttress plating as increased incidence of varus collapse has been reported.

Type V and VI fractures require open reduction and internal fixation to restore the joint stability, articular congruity & early mobilization[38]. The management of high energy Schatzker type V & VI fractures is done under two categories[3] 1) treatment of soft tissue injury and 2) treatment of bony injury.

Soft tissue envelope is allowed to heal by giving rest with or without traction or knee spanning external fixator with maximum of 21 days[1,3]. After soft tissue envelope has recovered, ORIF is done preventing the devastating complication possible on doing ORIF immediately.

Bony injury is managed by varied modalities like ORIF with plate osteosynthesis, Hybrid fixation, Illizarov ring fixation.

ORIF is done for anatomic restoration of the articular surface, restoration of the sagittal, coronal alignment of the proximal tibia, spanning severe metaphyseal comminution with bridging plates avoiding unnecessary dissection while providing alignment and adequate stability allowing early mobilization of knee[3].

ORIF is achieved from the following armamentarium of implants. T-buttress plate, L-buttress plate , Locking compression plate - all are side specific and cancellous screws with washer.

Locked plating system provide both angular and axial construct stability through a threaded interface which fixes the screw to the plate. Due to the inherent device stability, the need for compressing the plate to the bony surface is obviated, preserving the blood supply. Angular & axial stability of locked plates minimizes the risk of primary & secondary loss of reduction[1,3,12].

Hybrid & Illizarov fixation is primarily indicated in severe soft tissue injury with significant metaphyseal and subchondral comminution with resultant periarticular fragmentation[39,40]. Illizarov fixation provide good result in these cases[41].

Stamer et al has shown 70% good result in type VI injuries

Weiner et al has reported 82% good result

Mangal Parihar has shown good results by indirect reduction and external fixation.

The disadvantages of external fixation are that associated Meniscal injuries may be missed, wire discomfort and pain, pin site infections and septic arthritis[42].

MATERIALS AND METHODS

This is a prospective study conducted in Government Royapettah Hospital/Kilpauk Medical College, Chennai, from June 2006 to November 2008.

Twenty patients who satisfied the following criteria were included in the study.

Inclusion Criteria:

Tibial plateau fractures in adults

- Closed fractures
- Schatzker's type V and VI i.e. bicondylar fractures and bicondylar fractures with diaphyseo-metaphyseal dissociation.

Exclusion criteria:

Tibial plateau fractures

- In children
- Type I to Type IV
- Open fractures
- Late cases with joint stiffness
- Late cases with infection
- Cases of more than 30 days duration
- Cases with extensive soft tissue injury whose healing period was more than 21 days[3].

AGE DISTRIBUTION

Age Group (Years)	No. of patients	Percentage
21 - 30	2	10
31 - 40	3	15
41 - 50	7	35
51 - 60	6	30
>61	2	10

The mean age was 46.75 yrs

It ranged from 27 years to 62 years.

Most cases were between 41-60 years i.e. in the fifth & sixth decade about 65%.

SEX DISTRIBUTION

There was a male preponderance due to more active social lifestyle of males.

Number of male patients : 15 (75%)

Number of female patients : 5 (25%)

MODE OF INJURY

13 out of 20 cases were because of high-speed motor vehicle accidents.

7 cases sustained the fracture due to fall from height, which was mostly in cases of the elderly individuals.

Mode of Injury	No. of cases	Percentage
RTA	13	65
Fall from height	7	35

SIDE INVOLVED

Of the 20 patients Right side was fractured in 10 cases and in 10 cases left was involved.

Side	No. of cases	Percentage
Right	10	50
Left	10	50

FRACTURE TYPES

In our study of 20 cases, 9 (45%) were of type V,11 (55%) were of type VI fractures.

Schatzker Type	No. of Cases	Percentage
V	9	45
VI	11	55

ASSOCIATED INJURIES

11 (55%) cases were associated with other injuries. Two cases had associated LCL injuries. Two cases had Distal Radius

fracture and 2 had ACL injury, 1 had MCL tear, one had pelvic injury and 3 had meniscus injury.

PRE-OPERATIVE PERIOD

The period between the day of injury and the day of surgery ranged from 3 days to 12 days with a mean of 5 days.

MANAGEMENT

After the initial X-rays, patients were managed with knee aspiration for haemarthrosis if necessary and Above Knee slab. Skeletal traction was needed in 3 patients and Skin traction was applied in 3 patients in whom there was delay in the definitive treatment due to soft tissue injuries/associated injury/medical conditions[1,3].

Pre-operatively the fracture pattern was assessed with the antero-posterior, lateral, right oblique and left oblique views[28]. CT would help in assessing the fracture geometry, articular comminution and placement of trans-osseous wires[31,32].

The skin incision, approach and the placement of the implant and the number of screws and their direction are all planned in the pre-operative planning session. Templates are made and the screw sizes are measured and planned according to the fracture pattern.

PROCEDURE

The procedures were performed in standard operating rooms with the aid of image intensifier without laminar airflow. Prophylaxis with 3rd generation cephalosporin was routinely given before the start of surgery.

Position

Patient is positioned supine with a small sand bag under the gluteal region and a sterile bolster under the affected knee, which will provide the capability to flex the knee to 90 degrees.

Incision

According to the plan, lateral or medial Parapatellar incision was used. In our study lateral parapatellar incision was used in 16 cases & medial parapatellar in 4 cases.

Deep dissection is carried out and full thickness flaps are raised consisting of subcutaneous fat down to the fascia. Meniscus was preserved in all the cases and submeniscal arthrotomy was carried out to visualize the articular surface. The fracture geometry was studied well and then reduction done accordingly, checked & fixed provisionally with K-wires under the guidance of C-arm. As per the plan Locking compression plate/ buttress plate was placed and 6.5 mm cancellous screws applied and cortical screws applied in the diaphysis. Percutaneous screws were applied on the medial

side in lateral buttress plating to prevent the medial collapse of the articular surface.

Lateral plating was done in 16 cases and medial buttress plating in 4 cases. Bone grafting was done in 13 cases to restore the articular congruity and maintain the mechanical axis of the limb.

Post operatively the limb is rested in a well padded above knee slab. Intravenous third generation cephalosporin antibiotic is continued for 3 days post operatively and then orally for another 5 days. Suction drain maintained for 48 hours or until the drainage is minimal. Static Quadriceps exercise started from day 1 as tolerated by the patient. Once the pain and the tension in the operated site comes down they are started on gentle assisted motion. By the end of first week patients are started on active range of motion[44,45]. Suture removal done on 12th day. Patients are started on non-weight bearing crutch walking on discharge.

Follow up

They are then reviewed once in every 4 weeks and check X-rays are taken to assess the progression of fracture union. Weight bearing is usually delayed up to 12-16 weeks as these fractures are highly comminuted.

All the patients are then assessed clinically and radiologically by the following scoring systems

1. Knee society scoring system by Hospital for Special Surgery and
2. Rasmussen's Radiological assessment criteria

Follow up ranged between 8 months to 24 months and the mean follow up was 15.5 months.

CASE 1

Name	:Elumalai
Age/Sex	:42/M
Mode of Injury	:RTA
Extremity	:Left
Diagnosis	: Schatzker Type V Fracture
Time Interval between Injury and surgery	:3 days
Procedure	:ORIF with Lateral Buttress Plate
Post-op period	:Uneventful
Non-weight bearing mobilization	:3 days
Partial weight bearing	:12 weeks
Full weight bearing	:18 weeks
At follow-up	:20 months
Knee Society Score	:83
KSS Result	:Excellent
RRA Score	:14
RRA Result	:Good

CASE 2

Name	:Balaji
Age/Sex	:37/M
Mode of Injury	:RTA
Extremity	:Right
Diagnosis	: Schatzker Type VI Fracture
Time Interval between Injury and surgery	:7 days
Procedure	:ORIF with Locking Compression Plate with Bone graft
Post-op period	:Uneventful
Non-weight bearing mobilization	:5days
Partial weight bearing	:12 weeks
Full weight bearing	:18 weeks
At follow-up	:8 months
Knee Society Score	:92
KSS Result	:Excellent
RRA Score	:16
RRA Result	:Good

CASE 3

Name	:Seeralan
Age/Sex	:45/M
Mode of Injury	:RTA
Extremity	:Right
Diagnosis	: Schatzker Type V Fracture
Time Interval between Injury and surgery	:3 days
Procedure	:ORIF with Lateral Buttress Plate with Bone graft
Post-op period	:Uneventful
Non-weight bearing mobilization	:3 days
Partial weight bearing	:12 weeks
Full weight bearing	:18 weeks
At follow-up	:24 months
Knee Society Score	:89
KSS Result	:Excellent
RRA Score	:18
RRA Result	:Excellent

CASE 4

Name	:Varadarajan
Age/Sex	:42/M
Mode of Injury	:FFH
Extremity	:Right
Diagnosis	: Schatzker Type VI Fracture
Time Interval between Injury and surgery	:5 days
Procedure	:ORIF with Lateral Buttress Plate with Bone graft
Post-op period	:Uneventful
Non-weight bearing mobilization	:5 days
Partial weight bearing	:12 weeks
Full weight bearing	:20 weeks
At follow-up	:18 months
Knee Society Score	:94
KSS Result	:Excellent
RRA Score	:16
RRA Result	:Good

CASE 5

Name	:Rajesh
Age/Sex	:29/M
Mode of Injury	:RTA
Extremity	:Left
Diagnosis	: Schatzker Type VI Fracture
Time Interval between Injury and surgery	:3 days
Procedure	:ORIF with Medial Buttress Plate
Post-op period	:Uneventful
Non-weight bearing mobilization	:5 days
Partial weight bearing	:12 weeks
Full weight bearing	:18 weeks
At follow-up	:19 months
Knee Society Score	:64
KSS Result	:Fair
RRA Score	:10
RRA Result	:Fair

OBSERVATIONS

We have made the following observations from our study:

- Males sustained this fracture more than the females, the ratio being 3:1.
- Road traffic accidents are the most common mode of injury and it accounted for about 65% of the cases.
- Both limbs were equally involved i.e. 50% right, 50% left.
- About 13 out of the 20 cases were between 41 to 60 years i.e. about (65%)
- In the two cases above 60 years one patient had a minor fall and sustained type V fracture and the other had a RTA hit by a bicycle and sustained type VI fracture. Both the cases had a low energy injury but sustained a complex fracture due to the osteoporotic nature of the bone.
- We had almost equal distribution of type V and VI injuries 9 (45%) type V and 11(55%) type VI injuries.
- 11 patients had other associated injuries and remaining 9 patients had isolated tibial plateau fractures.
- Lateral parapatellar incision was used in 16 cases, and medial parapatellar incision in 4 cases.

- 9 cases were treated with locking compression plate (1 used medially & rest 8 laterally), 8 cases were treated with lateral buttress plating, 3 cases were treated with medial buttress plating.
- Bone grafting was required in 13 (65%) cases.
- Time required for union ranged from 12 to 20 weeks. Three case had superficial skin infection that had to be treated with antibiotics, debridement & regular dressing.
- Excluding the 3 cases that had infection, all other cases united between 12 to 18 weeks.
- Average time required for union was 15 weeks.
- Associated Medial Collateral Ligament Injury occurred in 1 patient; Lateral Collateral Ligament injury in 2 patients. All healed with conservative treatment by protective splinting[46,52].
- 2 patients had ACL tear as associated injury. ACL tear associated with proximal tibial fractures should normally be addressed after the fracture is stabilized and healed and after full knee motion is obtained with the patient being symptomatic[25,26]. In our study both the patients with ACL tear do not need further management at present.

- **Complications**[47]

1. **Infection** occurred in three cases, superficial infection that settled with appropriate antibiotics, debridement, regular dressing.
2. **Pain** –Occasional pain was seen in most patients. Mild pain while walking was present in 1case and moderate pain was present in 1 case.
3. **Knee stiffness –** Less than 90 degrees of ROM was present in 2 cases. In one case where there was infection the patient did not cooperate for rehabilitation. In one case due to associated pelvic injury patient could not be followed-up at regular interval that led to knee stiffness.
4. **Articular incongruity** – Less than 5 mm articular incongruity was seen in 5 cases but in those cases there was no major restriction of movements. 5-10 mm of depression was seen in 1 case.
5. **Malunion** – One case had malunion. This was in 60 yrs old, who had type VI fracture, but still he had good knee society score & good RRA result.

RESULT ANALYSIS

All the 20 patients were available for follow-up and they were followed up every month during the first 4 months and every 2 months during the first year. The minimum follow-up was 8 months and maximum was 24 months, mean follow-up being 15.5 months.

The results were analyzed both clinically and radiologically using two scoring systems.

1. Knee Society scoring system by Hospital for Special Surgery which is mainly a clinical scoring system and
2. Rasmussen's Radiological assessment criteria.

KSS in Schatzker type V fractures:

S. No	Result	No: of Patients
1.	Excellent	7
2.	Good	2
3.	Fair	0
4.	Poor	0

Out of 9 patients 7(78%) had excellent results and 2(22%) had good results.

KSS in Schatzker type VI fractures:

S. No	Result	No: of Patients
1.	Excellent	4
2.	Good	4
3.	Fair	2
4.	Poor	1

Out of 11 patients with Type VI fractures 4(36%) had excellent results, 4(36%) had Good results, 2(18%) had fair results and 1(9%) had poor result. The poor result was due to the associated pelvic injury which interrupted the regular post-op rehabilitation.

RRA in Schatzker type V fractures:

S. No	Result	No: of Patients
1.	Excellent	2
2.	Good	7
3.	Fair	0
4.	Poor	0

Out of 9 patients with type V fractures 2(22%) had excellent results and 7(78%) had good results according to Rasmussen Radiologic Assessment.

RRA in Schatzker type VI fractures:

S. No	Result	No: of Patients
1.	Excellent	0
2.	Good	8
3.	Fair	3
4.	Poor	0

Out of 11 patients with type VI fractures 8(73%) patients had good results and 3(27%) patients had fair results.

In our study we had 2 patients in 20 - 30 age group: Their mode of injury was RTA and the injury for both were on left side. One was type V fracture the other being type VI fracture. Type VI fracture patient had ACL tear. For type V fracture we used MBP with BG and for type VI we used MBP. Type VI patient had Fair results in both KSS scoring and RRA scoring. Type V patient had Excellent KSS and Good RRA scoring.

Result analysis of 20-30 age group:

S. No	Mode of Injury	Schatzker type	Procedure	KSS Result	RRA Result
1.	RTA	VI	MBP	Fair	Fair
2.	RTA	V	MBP č BG	Excellent	Good

Analysis of 31-40 age group gives the following results: Out of 3 patients one sustained injury due to fall and the other two due to

RTA. Two patients had type V and one type VI fracture. One of the type V patients had associated Meniscus Injury and was treated with LCP with KSS result being excellent and RRA scoring giving good result. The other type V patient had associated ACL tear and was treated with LBP yielding Good KSS result and Good RRA results. The type VI patient was treated with LCP with BG and had Excellent KSS scoring and Good RRA scoring.

Result analysis of 31-40 age group:

S. No	Mode Of Injury	Schatzker type	Procedure	KSS Result	RRA Result
1.	RTA	VI	LCPčBG	Excellent	Good
2.	FFH	V	LCP	Excellent	Good
3.	RTA	V	LBP	Good	Good

Analysis of patients in 41-50 age group: Out of the 7 patients 5 sustained injury due to RTA and 2 due to FFH. 4 patients sustained type V fracture and 3 type VI fracture. Meniscus injury was seen associated with one type V and one type VI fracture. Colle's fracture was seen associated with a type VI fracture. Out of the 4 type V fractures 2 were treated with LBP and 2 were with LCP. Out of the 3 type VI fractures 2 were treated with LBP and one with LCP.

Result analysis of 41-50 age group:

S. No	Mode of Injury	Schatzker Type	Procedure	KSS Result	RRA Result
1.	RTA	V	LBP	Excellent	Good
2.	RTA	V	LBPčBG	Excellent	Excellent
3.	RTA	V	LCP	Excellent	Excellent
4.	RTA	V	LCP	Excellent	Good
5.	FFH	VI	LBPčBG	Excellent	Good
6.	RTA	VI	LBPčBG	Good	Good
7.	FFH	VI	LCPčBG	Excellent	Good

Analysis of patients in 51-60 age group: Out of 6 patients 3 sustained injury due to RTA and 3 due to FFH. One sustained type V fracture and the rest type VI fracture. Type V fracture was treated with MBP and had excellent KSS and good RRA result.

Result analysis of 51-60 age group:

S. No	Mode of Injury	Schatzker Type	Procedure	KSS Result	RRA Result
1.	RTA	V	MBP	Excellent	Good
2.	FFH	VI	LCPčBG	Excellent	Good
3.	RTA	VI	LCPčBG	Poor	Fair
4.	FFH	VI	LCPčBG	Good	Good
5.	FFH	VI	LBPčBG	Good	Good
6.	RTA	VI	LBPčBG	Good	Good

Analysis of patients in above 60 age group: Out of 2 patients one had sustained injury due to minor RTA and one due to FFH. Both had associated LCL tear one had type V and the other had type VI fracture.

Result analysis of patients above 60 age group:

S. No	Mode of Injury	Schatzker Type	Procedure	KSS Result	RRA Result
1.	RTA	VI	LBPčBG	Fair	Fair
2.	FFH	V	LCPčBG	Good	Good

Result analysis for the type of implants used:

Analyzing the results for the type of implants used in our study revealed the following:

1. LBP was used in 2 cases. One had excellent and the other good result according to KSS scoring. Both had good RRA results.

KSS		RRA	
KSS Result	No. of patients	RRA Result	No. of patients
Excellent	1	Excellent	0
Good	1	Good	2
Fair	0	Fair	0
Poor	0	Poor	0

2. LBP with Bone Grafting was done in 6 patients.

KSS		RRA	
KSS Result	No. of patients	RRA Result	No. of patients
Excellent	2	Excellent	1
Good	3	Good	4
Fair	1	Fair	1
Poor	0	Poor	0

3. LCP was done in 3 patients.

KSS		RRA	
KSS Result	No. of patients	RRA Result	No. of patients
Excellent	3	Excellent	1
Good	0	Good	2
Fair	0	Fair	0
Poor	0	Poor	0

4. LCP with Bone Grafting was done in 6 patients.

KSS		RRA	
KSS Result	No. of patients	RRA Result	No. of patients
Excellent	3	Excellent	0
Good	2	Good	5
Fair	0	Fair	1
Poor	1	Poor	0

5. MBP was done in 2 patients.

KSS		RRA	
KSS Result	No. of patients	RRA Result	No. of patients
Excellent	1	Excellent	0
Good	0	Good	1
Fair	1	Fair	1
Poor	0	Poor	0

6. MBP with bone grafting was done in one patient. This patient had excellent result according to KSS and good result according to RRA.

Occasional pain is present in 10 patients, mild pain during climbing stairs alone in 7 patient, mild pain during walking in 1 patient and moderate pain in 1 patient.

On analyzing the Range of movements 3 cases had 120 degree range of movement,1 case had up to 115 degrees, 9 had up to 110 degrees, 5 had 100 degrees of movement and 1 case had 90 degrees of movement. 1 case had 80 degrees of movement. Patients with 90 and 80 degree of ROM had knee stiffness and hence had fair and poor results with respect to KSS score.

Analyzing the overall results and scores and grouping them under type V and VI, the average of the outcome scores are

Type	No. of Cases	Average KSS Score	Average Rasmussen Radiological Score
V	9	80.33	15
VI	11	80.58	15.16

COMPLICATIONS

COMPLICATION		**No. of CASES**
Superficial Infection		3
Knee Stiffness		2
Articular Incongruity		6
Pain	Occasional pain	10
	While Climbing stairs	7
	While Walking	1
	Moderate	1

DISCUSSION

Fractures of the tibial plateau have the potential to be devastating injuries especially when they have significant bony and soft tissue involvement along with knee instability and incongruity as in type V and VI injuries[48].

In this study, male:female ratio was 3:1. The majority of tibial plateau fractures reported in the recent literature have resulted from high speed motor vehicle accidents and fall from height[1,3,12]. In our study 65% of the fractures occurred as a result of high-energy motor vehicle accidents, and the rest 35% due to fall from height. Right side & left side had equal involvement 50:50%.

65% of cases were between 40 to 60 years i.e. 13 out of 20 cases in our study. 2 cases, both above 60 years sustained this complex fracture due to minor injury because of the osteoporotic nature of the bone.

Bone grafting was done in 13 of our 20 cases to maintain the articular congruity and most of our cases were taken up for fixation within 10 days of sustaining the fracture. Average time required for union was 15 weeks in our study and the weight bearing was delayed to around 12– 16 weeks[1,3].

Superficial infection occurred in 3 cases of our study, which settled with appropriate antibiotics, debridement & regular dressing.

Occasional pain was present in 10 cases, 7 had mild pain during climbing stairs alone, one had mild pan during walking and 1 had moderate pain. Radiologically 2 cases had articular incongruity ranging between 5- 10 mm.

Knee stiffness and ROM<90 deg was noted in 2 cases. One patient had malunion.

In the experience of Schatzker et al[8], 78% of tibial plateau fractures treated surgically had satisfactory results after 2.3 years. Lachiewicz and Funcik[49] examined the operative treatment of patients with 43 tibial plateau fractures and found 81% excellent results after 2.7 years.

In our study, we found that 85% of patients with type V and type VI Tibial Plateau Fractures, who were treated with ORIF with plate osteosynthesis had excellent or good clinical results by Knee Society Score of Hospital for Special Surgery[50,51]. Out of the 20 patients 11 had excellent, 6 good and 2 had fair results determined by KSS scoring.

According to Rasmussen radiological system, in our study we had 85% excellent to good results and 15% fair results.

We found no correlation between radiographic and clinical results, similar to two previous studies. This is because Rasmussen radiologic score does not take into account the location of articular depression or the amount of the joint surface involved.

CONCLUSION

From our study, we conclude that

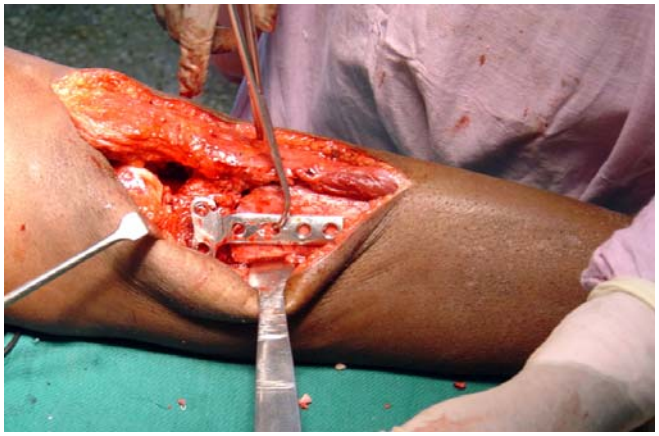
- Open reduction and internal fixation of closed type V and VI tibial plateau fractures is an effective method of treatment even with moderate soft tissue injury when adequate healing period is given.
- ORIF can restore the maximal joint stability and congruity, which are essential for articular cartilage regeneration[3].
- Early mobilization is absolutely essential for preventing the knee stiffness & for quick articular cartilage regeneration[44,45].
- Weight bearing should be delayed until solid union to prevent the articular collapse.
- Prognosis of this complex fracture depends on
    1. The degree of articular depression,
    2. The extent and separation of the condylar fracture lines,
    3. The degree of diaphyseal-metaphyseal comminution &
    4. The integrity of the soft tissue envelope.

    We found only mild difference in the average scores both clinically and radiologically in assessing the type V and VI fracture patterns. The average knee society score for type V was 80.33 and for type VI it was 80.58. The average RRS for type V was 15 and type VI 15.16.

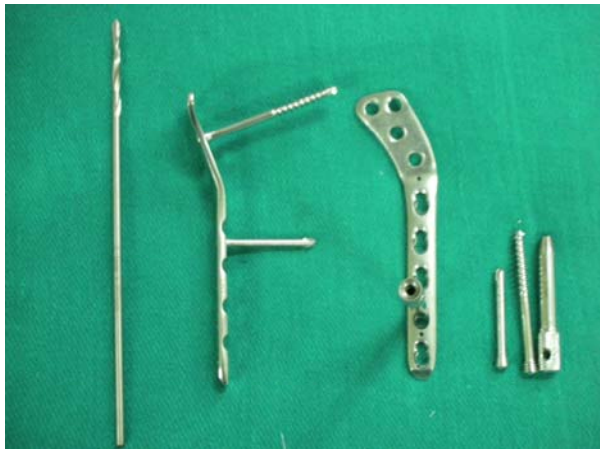
PATIENT POSITION

MIDLINE APPROACH

BUTTRESS PLATING

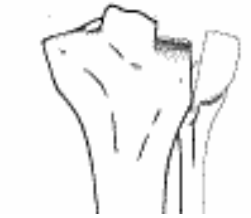


LCP INSTRUMENTATION



SCHATZKER CLASSIFICATION

Type I

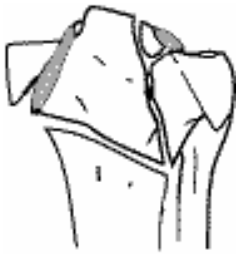


Type II

Type III

Type IV

Type V



Type VI

Schatzker's Classification

Type I

Type II

Type III

Type IV

Type V

Type VI

CASE I

PRE-OP LATERAL

PRE-OP AP

IMMED POST-OP AP

IMMED POST-OP LAT

8 MONTHS POST-OP LAT

8 MONTHS POST-OP AP

8 MONTHS POST-OP FLEXION

8 MONTHS POST-OP EXTENSION

CASE - II

PRE-OP

IMMED POST-OP

CLINICAL PHOTO

6 MONTHS FOLLOW-UP

CASE 3

PRE-OP

INTRA-OP

POST-OP AP

POST-OP LATERAL

CLINICAL PHOTO

CASE 4

18 MONTHS POST-OP AP

18 MONTHS POST-OP LAT

18 MONTHS POST-OP KNEE FLEXION

18 MONTHS POST-OP KNEE ROM

CASE 5

PRE-OP

IMMED. POST-OP AP

IMMED. POST-OP LAT

1. **David J. Jacofsky, George J. Haidukewych:** Tibial Plateau Fractures: *Insall Scott Surgery of the knee; ch - 66;1133-1146;4th edition;2006*
2. **Wiss DA, Watson JT, Johnson EE, Fractures of the knee. In: Rockwood CA, Green DP, Bucholz RW, et al:** Fractures in adults: *ed 4 Philadelphia: Lipincott - Raven 1996, p.1999.*
3. **William J. Mills MD, and Sean E. Norle, MD:** ORIF of high energy tibial plateau fractures: *OCNA;Page No.177 Vol 33 No.1 Jan 2002*
4. **Koval KJ, Helfel DL:** Tibial Plateau fractures-Evaluation and treatment: *J. Am. Acad. Orthop. Surg.1995; 3(2):86-94*
5. **Muller ME, Allgower, M. Schneider R. and Willenegger, H:** Manual of Internal fixation; *New York, Springer, 1979, p.256*
6. **Charnley J:** The closed treatment of common fractures: *Edinburgh Livingstone 1961*.
7. **Rasmussen PS:** Tibial condylar fracture as a cause of degenerative arthritis: *Acta Orthop Scan 43: 566-575; 1972.*
8. **Schatzker J, McBroom R, Bruce D:** The tibial plateau fracture. The Toronto Experience 1968-1975: *Clin Orthop 138:94-104; 1979.*
9. **Lasinger O, Bergman B, Korner L, Anderson GBJ:** Tibial Condylar fractures twenty year follow-up: *JBJS Am. Jan 1986; 68A;13-19.*
10. **Kettel Kemp DB; Hill Berry BM; Murrish DE et al:** Degenerative arthritis of the knee secondary to fracture malunion: *Clin Orthop 234: 159-169:1988.*
11. **Honkonen SE:** Indications for surgical treatment of tibial condylar fractures: *Clin Orthop: 302: 199-205: 1994.*
12. **Kenneth A, Egol & Kenneth J. Koval:** Fractures of the proximal tibia: *1999-2029; 6th edition 2006.*
13. **Burks RT, Gross Anatomy. Daniel et al:** Knee Ligaments: Structure, function, injury: *New York; Raven press; 1990;p.59-76.*
14. **Walker PS, Erkman MJ:** The role of the menisci in force transmission across the knee: *Clin Orthop; 109;184-192;1975.*
15. **Amy E Abbot, William N. Levine & Van C Mow:** Biomechanics of the adult knee: *John T. Callaghan; 2003; 81-144.*
16. **Bennett WF, Browner B:** Tibial Plateau fractures associated soft tissue injury: *J. Orthop. Trauma 8;183;1994.*
17. **Raja MS Khan MBBS, Shuja Hassan Khan MBBS, Agha Jamil Ahmad MD, Mohammed Umar MD:** Tibial Plateau fractures A new classification scheme: *CORR. 375;pp231-242;2000.*
18. **Schatzker J:** Fractures of the tibial plateau. *In. Chapman MW, Madison M(eds) Operative Orthopaedics Vol. Philadelphia, JB Lippincott 421-434;1988.*
19. **Honkonen SE, Jarvinen MJ:** Classification of fractures of the tibial condyles: *JBJS; 74B;840-847;1992.*

20. **Hohl M, Luck JV:** Fractures of the tibial condyle; A clinical and experimental study: *JBJS; 38A; 1001-1018;1956.*
21. **Hohl M, Moore TM:** Articular fractures of the proximal tibia: *In. Evartz CM(ed); Surgery of the musculoskeletal system; Vol 4; Ed.2;New York, Churchill Livingstone; 3471-3497;1990.*
22. **Moore TM:** Fracture Dislocation of the knee: *Clin Orthop; 156; 128-140;1981.*
23. **Rasmussen PS:** Tibial Condylar fractures. Impairment of knee joint stability as an indication for surgical treatment: *JBJS;55A; 1331-1350; 1973.*
24. **Douglas R. Dirsch MD and Patrick A Dawson MD:** Injury severity assessment in tibial plateau fractures: *CORR No.423; p.85-92;2004.*
25. **Delamarter RB, Hohl M, Hopp JM E:** Ligament Injuries associated with tibial plateau fractures: *Clin Orthop; 250;226-233;1990.*
26. **Srino Bharam MD, Mark S. Vrahas MD, Freddie H Fu MD:** Knee fractures in atheletes: *OCNA 33, 565-74; 202.*
27. **Lynch K, Johansen K:** Can doppler pressure measurement replace exclusive arteriography in the diagnosis of occult extremity arterial trauma: *AM Surgery; 214; 737-741;1991.*
28. **Scott D Gray MD, Phoebe A Kaplan MD, Robert G Dussault MD:** Imaging of the knee, current status: *OCNA Vol28; No.4;Oct 1991.*
29. **Dias JJ, Stirling AB, Finlay DB et al:** Computerised tomography for tibial plateau fractures: *JBJS Br.1987; 69(1);84-88.*
30. **Newberg AH:** Computed tomography of joint injuries: *Radiol Clin North Am;1990;28(2);445-460.*
31. **Chan PS, Klinkicwicz JJ, Luchetti WJ, et al:** Impact of CT Scan on treatment plan and fracture classification of tibial plateau fractures: *J.Orthop Trauma 1997;11(7);484-489.*
32. **Holt MD, Williams LA, Dent CM:** MRI in the management of tibial plateau fracture: *Injury;1995;26;595.*
33. **Kode L, Lieberman JM, Motta AO, et al:** Evaluation of tibial plateau fractures. Efficacy of MRI imaging compared with CT: *AMJ Roentgenol 1994;163(1);141-147.*
34. **David M. Hahn, MB Ch B, FRCS Ortho:** Current principles of treatment in the clinical practice of articular fracture: *CORR No.423, pp.27-32;2004.*
35. **Edwin P Su, MD, Geoffrey H, Westrich MD, Adam J Rana BA, Komal Kapoor BA, and David L. Helfet, MD:** Operative treatment of tibial plateau fractures in patients older than 55 years: *CORR No. 421; p 240-248;2004.*
36. **Harry A Mckellop, Ph.D., Adolfo Llina, MD, Augusto Sarmiento, MD:** Effects of tibial malalignment on the knee & ankle: *OCNA, Vol.25, No.3, July 1994; 415-423.*
37. **Thomas J. Gill MD, Darius M Moezzi MD, Kenneth M Oates MD, and William I Sterett MD:** Arthroscopic reduction and internal fixation of tibial plateau fractures: *CORR No.383, pp 243-249, 2001.*
38. **Ruth J:** Fractures of the tibial plateau: *Am J Knee Surgery; 14; 125-128; 2001.*

39. **Gaudinez RF, Mallik AR, Szporn M:** Hybrid external fixation of comminuted tibial plateau fractures: *Clin Orthop; 1996; 328; 203-210.*

40. **Kumar A, Whittle AP:** Treatment of complex (type VI) fractures of the tibial plateau with circular wire external fixation; Retrospective case review: *J.Orthop Trauma;2000; 14(5);339-344.*

41. **J. Tracey Watson MD, Steve Ripple MD, Susan J Hoshaw Ph. D., and David Fyhrie Ph.D:** Hybrid external fixation for tibial plateau fractures: *OCNA; Vol.33; No.1; Jan. 2002.*

42. **De Coster TA, Crawford MK, Learnt MA:** Safe extracapsular placement of proximal tibia transfixation pins: *J.Orthop Trauma 13; 236-240; 1991.*

43. **James B. Carr MD:** Surgical Techniques useful in the treatment of complex periarticular fractures of the lower extremity: *OCNA; Vol.25; No.4; Oct. 1994.*

44. **Salter RB, Simmonds DF, Malcolm BW et al:** The Biological effect of CPM on the healing of full thickness defects of articular cartilage: *JBJS; 62A; 1232-1251; 1980.*

45. **Gause Witz, Hohl M:** Significance of early motion in treatment of tibial plateau fractures: *Clin Orthop; 202; 135; 1986.*

46. **Indelicato PA:** Non-operative treatment of complete tears of the MCL of the knee: *JBJS; 65(A); 323; 1983.*

47. **Young MJ, Barrack RL:** Complications of internal fixation of tibial plateau fractures: *Orthop. Rev.23; 149-154; 1994.*

48. **Watson JT:** High energy fractures of the tibial plateau: *OCNA; 25; 723-752;1994.*

49. **Lachiewicz PF, Funcik T:** Factors influencing the results of open reduction and internal fixation of tibial plateau fractures: *Clin Orthop 259; 210-215; 1990.*

50. **Blokker CP, Rorrbeck CH, Bourne RB:** Tibial plateau fractures: An analysis of the results of treatment of sixty patients: *Clin orthop; 182; 193-194; 1984.*

51. **Biyani A, Reddy NS, Chaudary J et al:** The results of surgical management of displaced tibial plateau fractures in the elderly: *Injury 26; 291-297; 1995.*

52. **Kannus P:** Non-operative treatment of grade II & III sprains of the LCL injury of the knee; A prospective study: *Injury 20; 277; 1989.*

53.

PROFORMA

1. Patients Name :
2. Age :
3. Sex : Male / Female
4. Occupation / Income :
5. Address :
6. Associated Medical Illness : DM/HT/TB/IHD/Any other
7. Mode of Injury :
8. Involved side :
9. Time & Date of Injury :
10. Time of Arrival to Hospital :
11. Inpatient No :
12. Any Associated Injury :
13. Soft tissue injuries :
14. Vascular Complications : Yes / No
15. Compartmental Syndrome : Yes / No
16. Schatzker Classification :
17. Initial Management given :
    - Slab applied : Yes/No
    - Aspiration done : Yes/No
    - Traction : Yes/No
        i. Skin traction :
        ii. Skeletal traction :

18. CT/MRI/Arteriography :
19. Preoperative Antibiotics used :
20. Preoperative Transfusion :
21. Time interval between arrival & Surgery :
22. Date of Surgery :
23. Type of Anesthesia :
24. Surgical Procedure :
25. Approach used :
26. Implant used :
27. Bone grafting : Yes/No
28. Difficulty during surgery :
29. Blood loss during surgery :
30. Duration of surgery :
31. Post operative transfusion :
32. DT Removed on :
33. SR Done on :
34. Mobilization started on :
35. Immediate Post operative complications :

- Embolism
- Respiratory
- Infection

- Nerve injury
- Vascular

36. Limb length equality achieved : Yes / No

37. Partial Wt bearing started on :

38. Full Wt. Bearing started on :

39. Complications :

- Infection :
- Knee Stiffness :
- Pain :
- Articular Incongruity :
- Malunion :

40. KSS Score :

41. RRA Score :

MASTER CHART

S. No	Patient Name	Age	Sex	Mode of Injury	Involved side	Asso. Injury	Schatzker Type	Interval bet. Inj. & Surg	Procedure	Follow-up period	Knee Society Score			KSS Result	Complications	RRA	RRA Result
											Part 1	Part 2	Total				
1	Elumalai	42	M	RTA	Left		V	3	LBP	20	83	100	183	Excellent		14	Good
2	Balaji	37	M	RTA	Left		VI	7	LCP č BG	8	92	75	167	Excellent		16	Good
3	Seeralan	45	M	RTA	Right		V	3	LBP č BG	24	89	90	179	Excellent		18	Excellent
4	Varadarajan	42	M	FFH	Right		VI	5	LBP č BG	18	94	90	184	Excellent		16	Good
5	Rajesh	29	M	RTA	Left	ACL Tear*	VI	3	MBP	19	64	60	124	Fair		10	Fair
6	Parvathy	55	F	FFH	Left	Colle's #	VI	5	LCP č BG	12	87	75	162	Excellent		16	Good
7	Nobel	62	M	RTA	Right	LCL Tear	VI	7	LBP č BG	18	63	55	118	Fair	Skin, KS	10	Fair
8	Kamaraj	61	M	FFH	Right	LCL Tear	V	4	LCP č BG	14	78	70	148	Good		14	Good
9	Bharathy	58	F	RTA	Right	Pelvic Injury	VI	10	LCP č BG	15	51	15	66	Poor		10	Fair
10	Velu	52	M	RTA	Left		V	4	MBP	24	87	80	167	Excellent	Skin, KS	16	Good
11	Thendral	27	F	RTA	Left		V	3	MBP č BG	16	94	100	194	Excellent		16	Good
12	Md. Iqbal	52	M	FFH	Right	MCL Tear	VI	6	LCP č BG	17	79	80	159	Good		16	Good
13	Manohar	49	M	RTA	Left	Meniscus Inj	VI	5	LBP č BG	21	76	80	156	Good	Skin	16	Good
14	Anandan	52	M	FFH	Right		VI	4	LBP č BG	15	75	75	150	Good		16	Good
15	Shanmugham	38	M	FFH	Right	Meniscus Inj	V	4	LCP	10	82	80	162	Excellent		16	Good
16	Saravanan	33	M	RTA	Left	ACL Tear*	V	3	LBP	18	77	75	152	Good		16	Good
17	Janaki	42	F	RTA	Right		V	4	LCP	8	93	90	183	Excellent		18	Excellent
18	Mariappan	49	M	RTA	Right	Meniscus Inj	V	4	LCP	12	82	80	162	Excellent		16	Good
19	Pitchai	60	M	RTA	Left		VI	12	LBP č BG	10	78	75	153	Good	Malunion	16	Good
20	Kanmani	50	F	FFH	Left	Colle's #	VI	11	LCP č BG	11	90	80	170	Excellent		16	Good

ACL - Ant. Cruciate Lig
MCL, LCL - Collateral Ligs

LBP - Lateral Buttress Plating
MBP - Medial Buttress Plating
BG - Bone Grafting
LCP - Locking Compression Plate

RRA - Rasmussen Radiologic Assessment
KS - Knee Stiffness